SPECIAL REPORT

AN EXAMINATION OF THE DWARF MISTLETOE SITUATION IN WESTERN HEMLOCK FORESTS OF SOUTHEAST ALASKA

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SUMMARY

The damage potential and control of hemlock dwarf mistletoe has become an important issue in light of expanding forest management and timber harvest in southeast Alaska. The General Functional Inspection of Timber Management in Region 10 in 1968 recommended that the status of dwarf mistletoe be reevaluated. The Region accordingly invited Forest Service Pathologists Keith R. Shea (PNW Experiment Station) and James L. Stewart (Region 6) for a work trip to southeast Alaska to: (1) examine and evaluate the mistletoe problem, (2) help develop practical control procedures as needed, and (3) recommend studies on mistletoe control needs and practices. This was done in April and May, 1970.

Dwarf mistletoe was found to be extensive and damaging in many southeast Alaska forests. Some areas were heavily infected; others uninfected or lightly so. Where infection now is prevalent, damage in future stands likely will be greater unless the parasite is controlled. Present guidelines for applying control methods seem adequate but may merit some change as improved information becomes available.

As a result of the work trip, the authors of this report recommend the following:

A. Dwarf mistletoe control programs adapted to Alaska forest conditions should be continued and expanded.

B. Field training sessions for Ranger District personnel should be conducted to thoroughly acquaint them with the parasite, symptoms of infection, and currently recommended control practices.

C. Presale examination and mapping of sale areas are needed to determine the presence of dwarf mistletoe, define boundaries of mistletoe-infected portions of the sale area, and serve as a basis for developing control plans.

D. Appropriate Administrative-Research studies should be made to:

1. Estimate impact of hemlock mistletoe on the productivity of second-growth hemlock in

   a. natural second-growth stands, and

   b. thinned second-growth stands.

2. Improved control methods by determining

   a. minimum size of infected residual trees left after logging that will pose a threat to the new stand,

   b. mortality rates of infected residuals by time-after-clear-cutting and size classes, and

c. size at which hemlock reproduction becomes susceptible to infections which will produce mature mistletoe plants.

E. The services of forest pathologists skilled in experimental design and conduct of disease control operations should be acquired by one or more of the following alternatives:

1. Add a forest pathologist to the R-10 Insect and Disease Control staff.
2. Establish a Forest Disease Research Work Unit at the Institute of Northern Forestry (INF).
3. Arrange with R-6 and/or the PNW Station to detail a pathologist periodically to assist in the research, training, and control programs until staffing can be obtained.

INTRODUCTION

Timber harvesting now is extensive in hemlock and Sitka spruce-hemlock forests of southeast Alaska. Planning for further development of the area is well underway. Forest managers are looking ahead to improve forest management practices to retain and increase forest amenities and timber values.

Factors which may negate management projections are receiving special attention. Among these, dwarf mistletoe of western hemlock is of particular concern. Until recently, this parasitic plant was regarded primarily as an interesting part of the flora. But the increased importance of western hemlock to the economy brought attention to the large brooms, associated knots, related decay, and to mortality and general decline of stands in which dwarf mistletoe infection is prevalent. Questions also were raised as to the potential damage dwarf mistletoe might cause in the future second-growth forests.

After an inspection trip, Mr. Charles Rindt recommended in the 1968 General Functional Inspection of Timber Management in Region 10 ---

> "Although there have been some investigations and reports on hemlock mistletoe in Alaska, they do not effectively handle some of the important questions of practical timber management. The Region should install administrative studies, with appropriate help from the Station, to develop a practical approach to mistletoe control on cut over areas."

As a followup to this recommendation, Forest Service pathologists Keith R. Shea (PNW Experiment Station) and James L. Stewart (Region 6) were invited by the Institute of Northern Forestry and Region 10 to examine the dwarf mistletoe situation in southeast Alaska during April 26 - May 11, 1970 and recommend appropriate steps to be taken.

Specific objectives of the work trip were to --

A. examine and evaluate the dwarf mistletoe problem in southeast Alaska,

B. provide a framework for development of practical controls based on current knowledge, judgment, and forest management practices, and

C. recommend administrative-research studies to answer specific questions on dwarf mistletoe control needs and practices.

The areas visited and conditions observed are summarized in the Appendix. Mistletoe in western hemlock was examined near Juneau and on the Petersburg, Sitka, and Craig Ranger Districts. Old-growth and second-growth hemlock and mixed hemlock-spruce stands and mistletoe control operations were examined.

BACKGROUND

The dwarf mistletoes (Arceuthobium spp.) are perennial, dioecious, seed-bearing parasites on coniferous hosts. The dwarf mistletoe plant is composed of an endophytic system ("roots"), a stem, vestigial leaves, and reproductive organs. The genus Arceuthobium has numerous species; most parasitize one primary host. A. campylopodum f. tsugensis attacks western hemlock and mountain hemlock and occasionally other associated conifers; it seldom damages hosts other than hemlock.

This dwarf mistletoe flowers and is pollenated (presumably by insects) in the spring and fruits in the fall of the following year. When the fruits are ripe, the seed are ejected forcibly for considerable distances. The seed are coated with a sticky, hygroscopic substance (viscin) which dries and affixes the seed to the host. After over-wintering, seed germinate in the spring, penetrate host tissues, and establish new infections. Aerial shoots usually appear within 3 to 5 years, but infections may remain dormant for 10 or more years before the aerial shoots develop.

Spread and intensification depend primarily on localized seed dispersal from a fruiting female plant. Long-distance spread, probably by birds carrying the seed, is limited because both male and female plants must develop in reasonably close proximity to each other. From a practical viewpoint, only local spread is of concern to forest managers.

Dwarf mistletoes are most severely damaging in all-aged forests. The parasite rapidly intensifies where overstory infections can disperse seed to understory trees. Once the overstory infections are eliminated, lateral spread in even-aged stands is relatively slow because of the screening effect one tree has for the next. In even-aged infected stands, however, thinning to improve tree growth generally favors intensification of the parasite in infected trees. Because the screening effect is reduced in thinned stands, tree-to-tree spread also may increase depending upon tree spacing.

Control of dwarf mistletoe in hemlock is based upon removal of the infected overstory in logging operations and destruction of all infected residuals before the regeneration is infected. Sanitation of infected young hemlock stands may be accomplished by cutting all infected trees with later followup to remove trees with missed infections. Pruning to remove infected branches seldom is justified because of excessive costs, the difficulty of finding all infections with aerial shoots, and the prevalence of dormant or latent infections without aerial shoots which cannot be readily detected.

Hemlock mistletoe has not been studied to any extent in Alaska. However, results of studies and recommendations for control in the hemlock type elsewhere indicate the damage potential of the parasite and suggest methods for control. In British Columbia, for example,

volume loss was nearly 60 cubic feet/acre/year for dominant and co-dominant hemlocks averaging 110 years on site index 140 (Canadian Jour. Botany 15: 227-285). In another study, also in British Columbia, 10 evenly spaced, residual hemlock per acre left after clear felling were judged sufficient to infect all hemlock regeneration (Forestry Chronicle 42: 395-401). Clear-cutting in as large blocks as possible followed by destruction of all infected residuals has been suggested as effective control measures in British Columbia (B.C. Lumberman 36(5): 50-51, 136, 138) and coastal Washington (Weyerhaeuser Forestry Paper 9, 1966).

CONCLUSIONS AND RECOMMENDATIONS

Distribution and Damage - Based on our observations, dwarf mistletoe is prevalent on western hemlock throughout much of southeast Alaska. Institute of Northern Forestry files record the parasite in the Haines area, but it has not been found north of Icy Strait to the west. However, it is absent from many southeast Alaska hemlock stands -- some are mistletoe-free, others infected, some severely so.

From our observations, we believe dwarf mistletoe is causing serious impact, comparable to that reported in British Columbia, in many hemlock stands. The impact entails growth loss, deformities and cull, general decadence, and predisposition of trees to damage or death from other agents. Unless infected residuals remaining after current logging are cut or killed, mistletoe damage probably will be greater in future stands than in present ones. Only a few infected trees per acre are required to infect incoming hemlock regeneration. Infection will, therefore, occur earlier and intensify more rapidly in these regenerating forests so long as an overstory source of infection remains. Although quantitative data are lacking for southeast Alaska, the available evidence suggests that growth and quality reduction warrant direct control action.

We recommend, therefore, that control programs be continued and expanded in southeast Alaska.

Present Control Practices - The present control program specifies cutting all residual whips 4-in d.b.h. or 4 feet tall and larger (previously 2-in. d.b.h. and 4 feet tall) after clear-cutting. Control as practiced on the Petersburg Ranger District in the Three Lakes and Blind River Sale areas appears biologically sound and highly effective at an average cost of $14/A. Until more facts are available, we think the present guidelines for control in clear-cuts are adequate. The residuals should be cut as soon as possible after logging. For the present, cutting of residuals should not be deferred more than three years after logging.

Some reinvasion of the regenerated hemlock stand will occur along infected cutting boundaries and seed strips. Under present cutting practices, we do not think this infection source will be economically serious enough to justify additional expenditures for control in border trees. However, if the size of clear-cuts is reduced to less than 40 acres, the relative importance of infected trees bordering the clear-cuts likely will increase; it may then be necessary to include these border infection sources in the control program.

If selective cutting is practiced, other guidelines for mistletoe control will need to be developed for use in infected stands. For example, in spruce-hemlock stands the infected hemlock overstory could be cut first and the advance hemlock reproduction destroyed, leaving the old-growth spruce for later. Such a logging system could be used where preservation of the aesthetic qualities of the landscape is

paramount. However, clear-cutting followed by eradication of infected residuals remains the most effective control method available.

Recommendations for Improvement of Control - The dwarf mistletoe control program in southeast Alaska is relatively new and not all field personnel are thoroughly acquainted with the mistletoe problem and its control.

We recommend field training sessions for appropriate Ranger District personnel to thoroughly acquaint them with the parasite, the symptoms of infection, and the currently recommended control practices.

Improvements in effectiveness and overall economy of the current control program could be achieved by restricting control to the infected portions of the timber sale area.

We recommend presale examinations and mapping of sale areas to: (1) determine the presence of dwarf mistletoe, (2) define boundaries of the mistletoe-infected portion of the sale area, and (3) serve as a basis for developing control plans.

The presale examinations and mapping should be done prior to sale layout and harvest for these reasons:

1. Mistletoe symptoms are more easily detected in old-growth and accurate mapping of mistletoe-infected portions of the stand, therefore, is easier before harvest.
2. Sale boundaries can be altered to include entire infected patches to minimize spread of mistletoe back into the new stand.

3. Residual whips need be removed for mistletoe control only in infected portions of clear-cuts. A map would show where control dollars should be spent to achieve the greatest return.

If item "2" above cannot be accomplished and a clear-cut unit must border on an infected stand, the unit should have a large area-to-perimeter ratio. The unit should be large enough so initial mistletoe invasion of the new stand in an approximately one-chain wide area will not cause significant losses to the new stand as a whole. Although adequate information is not available, we suggest a 40-acre clear-cut as the smallest acceptable size when adjacent to an infected old-growth stand.

The current control procedures with the above modifications appear simple. However, questions arise in actual application, for example:

1. What is the minimum size residual whip that needs to be cut? Control costs escalate rapidly as whip size decreases.
2. How soon after logging must infected whips be cut to prevent infection of new trees? An answer to this question would provide greater flexibility in timing of control work.
3. How important is removal of infected residual whips in stands with spruce and hemlock in varied mixtures? Mixed stands may or may not require as strict control as pure hemlock stands, depending upon management objectives and the mix of species attainable. Until composition of the new stand can be reliably determined, however, dwarf mistletoe control should be provided.

4. How long do infected residuals of various sizes and ages live after the clear-cut? Timing the control operation to take advantage of mortality could reduce costs if additional infection of the regenerating stand does not occur in the interim.

Recommended Administrative-Research Studies - These and other questions require answers to improve present control practices and cost-effectiveness. Suggested studies are listed below.

1. Estimate Impact of Hemlock Mistletoe - An estimate of the impact of mistletoe on the productivity of second-growth hemlock in southeast Alaska would quantify the problem and assess damage potential. Two types of studies should be made:

   a. Effects of hemlock mistletoe on productivity of second-growth. Compare growth (diameter, height, volume) of infected and healthy hemlock on similar sites by age classes. Stratification of samples might be difficult, since extensive cutting has not occurred in the past. Paired plots (infected vs. uninfected) in small "fish trap" or piling cuttings might provide opportunities to sample the varied soils and sites in southeast Alaska.

   b. Effects of hemlock mistletoe on productivity in thinned stands. Thinning can be expected to become a tool in hemlock management, so studies should be started to

determine: (1) the rate of mistletoe intensification in stands thinned to various spacings, and (2) volume loss in thinned infected and uninfected stands versus unthinned infected stands. These studies are not as urgent as "a" above and could be established in conjunction with thinning studies.

2. Improve Control Methods - Control practices must be highly efficient to extend effective coverage at the least cost. Three types of studies are indicated:

   a. Minimum size of infected residual. Knowing the smallest infected hemlock that would pose a significant threat to the new stand would permit improved efficiency in control operations.

   b. Mortality rates of infected residuals. The rates at which infected residuals left after clear felling die, by time and size classes, would permit improved timing of control operations to achieve maximum effectiveness at least costs.

   c. Size at which hemlock reproduction becomes susceptible to infection. This study needs to clarify not only the size at which hemlock can become infected but also the size needed for mature, seed-producing, mistletoe plants to develop.

Studies 1a, 1b, 2a, and 2b should be jointly designed and conducted as Administrative-Research studies. Study 2c should be primarily a research responsibility.

Other Recommendations - Conduct of the recommended Administrative-Research studies and an expanded control program requires forest pathologists skilled in design of experiments and in conduct of disease control operations.

We therefore recommend consideration of the following:

1. Region 10 should add a forest pathologist to the Insect and Disease Control staff to facilitate the mistletoe control program and carry out Administrative-Research studies.
2. A Forest Disease Research Work Unit should be established at the Institute of Northern Forestry.
3. Until professional pathology advice and assistance is available at the Institute of Northern Forestry and in Forest Insect and Disease Control, arrangements should be made with Region 6 and/or the PNW Station to detail a pathologist periodically to assist in study design and establishment, training of forest personnel, and evaluation of control projects.

We wish to thank all Forest Service personnel who made the Work Trip effective and enjoyable by their thorough planning, stimulating discussions, and the many courtesies extended. We hope our suggestions will prove useful in improving forest management practices in southeast Alaska.